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Title	Ultra thin glass sheet based micro-sensor for cell physical properties measurement
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Citation	大阪大学, 2023, 博士論文
Version Type	
URL	https://hdl.handle.net/11094/92898
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Form 3

Abstract of Thesis

Name (YAPENG YUAN)	
Title	Ultra thin glass sheet based micro-sensor for cell physical properties measurement (超薄板ガラスを用いた細胞物性測定用の高感度センサーの開発)

Abstract of Thesis

Cell mechanical properties play vital roles in many biological activities and functions, such as cell growth, cell division and cell migration. Micro-cantilever based sensor platform has become a promising technique for the cell mechanical properties measurement. Compared to some other common materials available for the fabrication of cantilevers used in the sensing platform, glass-based devices made of ultra-thin glass sheet (UTGS) are transparent and physically and chemically stable, which allow high resolution and real-time observation during measurement process. Additionally, The UTGS with a thickness of 10 μm exhibits good flexibility making it suitable for the micro-cantilever fabrication for cell mechanical properties measurement. Using microfabrication and biological elements, the main proposal of this thesis is to explore some special techniques for UTGS fabrication and devices for cell mechanical properties measurement with convenience, accuracy, sensitivity and efficiency.

In the first part of this research, using the thermal stretching method integrated with a weight-controlled load (WCL), I developed a convenient and efficient method for the fabrication of an independent UTGS (≤ 3 μm, the thinnest of the UTGS could reach 900 nm, the world's thinnest). Compared with traditional methods, the key factor of the proposed method is using a WCL to precisely stretch a commercial thick glass plate to achieve the desired glass sheet thickness without a full melting of the glass material. The fabricated UTGS was flexible, elastic, and physically and chemically stable, optical transparent, and had a good surface condition, indicating its potential as a component in different biological fields including clinical chemistry instrumentation, biological analytical and synthesis fields.

In the second part, taking high flexible performance of the fabricated UTGS, an UTGS-based pressure sensor was designed and fabricated to realize low pressure detection (0-600 mbar) with high sensitivity in micro-systems. For the same working conditions, the maximum sensitivity of the new pressure sensor was improved by 86.8% compared with the sensitivity previously obtained.

Lastly, this thesis proposed an ultra-thin (10 μm), highly sensitive, and flexible glass cantilever integrated with strain gauge sensor and its application for the measurement of single-cell mechanical properties. Compared to the conventional methods, the proposed UTGS-based cantilever is easy for fabrication, owns excellent optical transparency, stable physical and chemical properties, and shows a high linear relation between resistance change and applied small force/displacement.

In summary, this thesis described the convenient UTGS fabrication technique and UTGS-based cantilever for cell mechanical properties measurement, which are very efficient and practical to solve the problems that existed in biological field.

様式 7

論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

細胞の力学的特性は多くの生命機能において重要な役割を担っている。細胞の力学的特性を測定するために、マイクロカンチレバーを用いた手法がよく用いられている。苑 亜鵬（Yapeng Yuan）氏は、本論文において、マイクロカンチレバーに利用可能な超薄板ガラスを作製する手法を開発し、生物試料への応用を想定した細胞力学特性計測デバイスを開発した。従来のマイクロカンチレバーに比べて、優れた光学的透明性、安定した物理的・化学的特性を有しており、世界最薄の900nmに到達する超薄板ガラスの作成法の開発に成功した。また、ガラスカンチレバーと歪みゲージセンサーを一体化することで、卵や単細胞生物の力学特性計測に適用した。これらの成果は、細胞の力学的特性の理解を進めるものであり、メカノバイオロジーや生物物理学の研究分野に寄与することから、博士の学位を授与するに値するものと認める。

なお、チェックツール“iThenticate”を使用し、剽窃、引用漏れ、二重投稿等のチェックを終えていることを申し添えます。